Qualification Accredited

OCR
Oxford Cambridge and RSA

A LEVEL

BIOLOGY A
BIOLOGY B (ADVANCING BIOLOGY)

H420, H422

For first teaching in 2015

Practical Activities Support Guide

Version 1.3

Contents

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Introduction

This Practical Activities Support Guide is designed to provide support specifically around how our Practical Activity Group (PAG) suggested activities can be adjusted by centres and revision support for our specification's learning outcomes in 1.1 Practical skills assessed in a written examination. This guide supplements our existing resources regarding the Practical Endorsement, including:

- Positive about Practical
    - This page features videos outlining our PAG approach to the Practical Endorsement. It also contains links to cross-board communications relating to the Practical Endorsement and monitoring.
- Practical Endorsement FAQs
- Practical Skills Handbook
    - This is a comprehensive handbook which describes the assessment of practical skills in the AS and A Level specifications, including the requirements of the Practical Endorsement and guidance on planning a practical scheme of work.
- OCR Science Practical Endorsement Training Site
    - Lead teachers are required to have undertaken this free online training and should ensure all other teachers are familiar with the requirements. We recommend that, for the purpose of standardisation within your centre, all teachers who assess the Practical Endorsement undertake the training.
- PAG teacher and student sheets
- Science Coordinator Materials
    - This is where secure documents are held including answers for the questions in the PAG student sheets and the PAG trackers.
- Specifications (Biology A and Biology B)
    - Most notably this includes:
        - Module 1.1 Practical skills assessed in a written examination
        - Module 1.2 Practical skills assessed in the practical endorsement
        - Section 5 Practical Endorsement appendix
- PAG Practice question sets

The Practical Endorsement

Extract from the Practical Skills Handbook:

The Practical Endorsement is directly assessed by teachers and is a mandatory part of the A Level qualification. The assessment is certificated as Pass or Not-classified. As part of the Head of Centre declaration that centres must submit every year, any centre offering A Level Biology must declare that they have provided students with the opportunity to complete practical work towards the Practical Endorsement.

In order to achieve a Pass, candidates will need to have met the expectations set out in the Common Practical Assessment Criteria (CPAC) (see Table 2 in the specification, Appendix 5) including demonstrating competence in all the skills, apparatus and techniques in sections 1.2.1 and 1.2.2 of each specification.

Learners may work in groups, but must be able to demonstrate and record independent evidence of their competency. This must include evidence of independent application of investigative approaches and methods to practical work.

Teachers who award a Pass need to be confident that the candidate consistently and routinely exhibits the required competencies before completion of the A Level course.

The PAG Approach

Candidates can demonstrate these competencies in any practical activity undertaken throughout the course of study. The 12 OCR Practical Activity Groups (PAGs) described in the specification provide opportunities for demonstrating competence in all required skills, together with the use of apparatus and practical techniques for each subject.

Using our suggested practical activities is **not** mandatory. You can use the suggested practical activities from the Practical Activity Groups (PAGs), your own activities, or activities from other publishers to assess student practical skills. If you use activities other than our suggested practical activities, you need to ensure that you have mapped these activities to the relevant 1.2.1 and 1.2.2 criteria and the CPAC so you can track student progress in these.

In the OCR specifications, 12 PAGs are presented, within each PAG are 3-4 suggested activities. None of these activities are explicitly required. Instead, the PAG approach gives some possible routes for students to learn the practical skills in the AS and A Level specifications and to achieve the Practical Endorsement.

At least 15% of the marks in examinations will assess practical skills. Examinations will not assume candidates have carried out all of these activities. However, they **will** assume that students are familiar with specific practical aspects mentioned in modules 2-6 (Biology A) and 2-5 (Biology B), as well as those from the 1.2.2 criteria which students will have covered during the course of the Practical Endorsement. Questions may test the application of practical skills in novel and familiar contexts.

You are free to make changes to our suggested activities, but if these changes change which parts of 1.2.1, 1.2.2 and the CPAC you are assessing you will need to make sure this is reflected in your tracking of student progress.

Health and safety

For additional health and safety guidance, please refer to CLEAPPS.

The CPAC and our specifications

The CPAC criteria is very closely linked to our specification learning outcomes in 1.2.1 Practical skills. Below, we have mapped out how these learning outcomes map to the CPAC criteria as well as our PAG activities.

In addition, we have also mapped out how our PAG activities relate to our specification's 1.2.2 Use of apparatus and techniques learning outcomes.

PAG vs CPAC and 1.2.1

This table shows how our suggested practical activities in the PAGs relate to both the CPAC and our specification's 1.2.1 Practical skills learning outcomes.

PAG	CPAC 1: Follows written procedures	CPAC 2: Applies investigative approaches and methods when using instruments and equipment		CPAC 3: Safely uses a range of practical equipment and materials		CPAC 4: Makes and records observations			CPAC 5: Researches, references and reports		
1.2.1	**c)** follow written instructions	**a)** apply investigating approaches to practical work	**g)** use appropriate software and tools to process data, carry out research and report findings	**b)** safely use a range of practical equipment & materials	**j)** use a wide range of experimental and practical instruments, equipment and techniques	**d)** make and record observations/ measurements	**e)** keep appropriate records of experimental activities	**f)** present information and data in a scientific way	**g)** use appropriate software and tools to process data, carry out research and report findings	**h)** use online and offline research skills including websites, textbooks and other printed scientific sources of information	**i)** correctly cite sources of information
1.1	✓				✓		✓				
1.2	✓			✓	✓	✓	✓	✓			
1.3	✓			✓	✓	✓	✓	✓			
2.1	✓			✓	✓	✓	✓	✓			
2.2	✓			✓	✓	✓	✓	✓			
2.3	✓			✓	✓	✓	✓	✓			
3.1	✓			✓	✓	✓	✓	✓			
3.2	✓			✓	✓	✓	✓	✓			
3.3		✓		✓	✓	✓	✓	✓			
4.1	✓			✓	✓	✓	✓	✓			
4.2	✓			✓	✓	✓	✓	✓			
4.3		✓		✓	✓	✓	✓	✓			
5.1	✓			✓	✓	✓	✓	✓			
5.2	✓			✓	✓	✓	✓	✓			
5.3	✓			✓	✓	✓	✓	✓			
6.1	✓			✓	✓	✓	✓	✓			
6.2	✓			✓	✓	✓	✓	✓			
6.3	✓			✓	✓	✓	✓	✓			

PAG	CPAC 1: Follows written procedures	CPAC 2: Applies investigative approaches and methods when using instruments and equipment		CPAC 3: Safely uses a range of practical equipment and materials		CPAC 4: Makes and records observations			CPAC 5: Researches, references and reports		
7.1	✓			✓	✓	✓	✓	✓			
7.2	✓			✓	✓	✓	✓	✓			
7.3	✓			✓	✓	✓	✓	✓			
8.1	✓			✓	✓	✓	✓	✓			
8.2	✓			✓	✓	✓	✓	✓			
8.3		✓		✓	✓	✓	✓	✓			
9.1	✓			✓	✓	✓	✓	✓			
9.2	✓			✓	✓	✓	✓	✓			
9.3	✓			✓	✓	✓	✓	✓			
10.1	✓				✓	✓	✓	✓	✓		
10.2		✓		✓	✓	✓	✓	✓	✓		
10.3		✓		✓	✓	✓	✓	✓	✓		
11.1	✓	✓		✓	✓	✓	✓	✓			
11.2		✓		✓	✓	✓	✓	✓			
11.3		✓		✓	✓	✓	✓	✓			
11.4		✓		✓	✓	✓	✓	✓			
12.1		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
12.2		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
12.3		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

PAG vs 1.2.2

This table shows how our suggested practical activities in the PAGs relate to our specification's 1.2.2 Use of apparatus and techniques learning outcomes.

1.2.2	**a)** use of appropriate apparatus to record a range of quantitative measurements (to include mass, time, volume, temperature, length and pH)	**b)** use of appropriate instrumentation to record quantitative measurements, such as a colorimeter or potometer	**c)** use of laboratory glassware apparatus for a variety of experimental techniques to include serial dilutions	**d)** use of a light microscope at high power and low power, including use of a graticule	**e)** production of scientific drawings from observations with annotations	**f)** use of qualitative reagents to identify biological molecul	**g)** separation of biological compounds using thin-layer/paper chromatography or electrophoresis	**h)** safe and ethical use of organisms to measure: **(i)** plant or animal responses **(ii)** physiological functions	**i)** use of microbiological aseptic techniques, including the use of agar plates and broth	**j)** safe use of instruments for dissection of an animal or plant organ	**k)** use of sampling techniques in fieldwork	**l)** use of ICT such as computer modelling, or a data logger to collect data, or use of software to process data.
1.1	✓			✓	✓							
1.2	✓			✓	✓							
1.3	✓			✓	✓							
2.1	✓				✓					✓		
2.2	✓			✓	✓					✓		
2.3	✓				✓					✓		
3.1	✓				✓						✓	
3.2	✓				✓						✓	
3.3	✓				✓						✓	
4.1	✓		✓									
4.2	✓		✓									
4.3	✓											
5.1	✓	✓										
5.2	✓	✓	✓									
5.3	✓	✓										
6.1	✓						✓					
6.2	✓						✓					
6.3	✓						✓	✓				

1.2.2	**a)** use of appropriate apparatus to record a range of quantitative measurements (to include mass, time, volume, temperature, length and pH)	**b)** use of appropriate instrumentation to record quantitative measurements, such as a colorimeter or potometer	**c)** use of laboratory glassware apparatus for a variety of experimental techniques to include serial dilutions	**d)** use of a light microscope at high power and low power, including use of a graticule	**e)** production of scientific drawings from observations with annotations	**f)** use of qualitative reagents to identify biological molecul	**g)** separation of biological compounds using thin-layer/paper chromatography or electrophoresis	**h)** safe and ethical use of organisms to measure: **(i)** plant or animal responses **(ii)** physiological functions	**i)** use of microbiological aseptic techniques, including the use of agar plates and broth	**j)** safe use of instruments for dissection of an animal or plant organ	**k)** use of sampling techniques in fieldwork	**l)** use of ICT such as computer modelling, or a data logger to collect data, or use of software to process data.
7.1	✓				✓				✓			
7.2	✓		✓		✓				✓			
7.3					✓				✓			
8.1	✓		✓									
8.2	✓		✓									
8.3	✓	✓	✓									
9.1						✓						
9.2						✓						
9.3						✓						
10.1	✓											✓
10.2	✓	✓										✓
10.3	✓		✓									✓
11.1	✓							✓				
11.2	✓			✓	✓			✓				
11.3	✓							✓				
11.4	✓		✓					✓				
12.1	✓											
12.2	✓							✓				
12.3	✓											

PAG 1: Microscopy

Minimum techniques/ skills to be covered:

- Use of a light microscope at high power and low power, use of a graticule
  - If not covered in **PAG 2**.
- Production of scientific drawings from observations with annotations
  - If not covered in **PAG 2** or **PAG 3**.

Suggested activities	1.2.1 practical skills covered	1.2.2 apparatus and techniques covered
1.1: Using a light microscope to study mitosis	c, e, j	a, d, e
1.2: The examination and drawing of blood cells observed in blood smears	b, c, d, e, f, j	a, d, e
1.3: Using a light microscope to examine lung tissue	b, c, d, e, f, j	a, d, e

Overview

This Practical Activity Group includes best practice use of a light microscope to observe slides, calibrate an eyepiece graticule to make measurements using a stage micrometer and make annotated scientific drawings. **PAG 1.2** includes the preparation of a wet mount of mammalian blood.

Possible adjustments

It is relatively straightforward to adjust this PAG to use any prepared microscope slides which are available at your centre. It is an option for students to prepare a variety of slides, such as plant cell slides using onion epidermis, yeast suspension cells, hay infusion, root tip squashes, although this is not a requirement of any of the PAGs.

PAG 1.1 and the alternative Measuring stomatal density practical below could be completed in a non-laboratory setting so long as the microscopes and slides are available.

Support resources

These resources may be useful for teachers when planning/adjusting PAGs or for students when they are revising for the specification's learning outcomes in 1.1 Practical skills assessed in a written examination.

HANDBOOK: OCR – Drawing Skills Handbook

- https://www.ocr.org.uk/Images/251799-biology-drawing-skills-handbook.pdf
- This resource explains the requirements of good biological drawings and includes a common errors activity.

- **VIRTUAL LIGHT MICROSCOPE: BioNetwork – Virtual microscope**
  - http://www.ncbionetwork.org/iet/microscope/
  - This is a brilliant virtual microscope which includes information on light microscopes and their structure. It also includes an "explore" section where different slides can be viewed and their focus and magnification adjusted. There is then a "test" option with quiz questions which give immediate feedback.

- **RESOURCED LESSON OUTLINE: Cambridge International – Investigating mitosis by preparing a root tip squash**
  - https://learning.cambridgeinternational.org/classroom/course/view.php?id=3639
  - This is a very comprehensive resource. It includes a video (with transcript) outlining the whole procedure for preparing a root tip squash to observe the stages of mitosis. It also has a teacher walkthrough version of the video, which includes additional notes such as justification of different steps, and a Teaching Pack. This includes a scheme of work for 4 one hour long lessons around this investigation. This is much more in depth than is required to cover the PAG but could be very useful when teaching 2.1.6 Cell division, cell diversity and cellular organisation (Biology A) or 3.1.1 The developing cell: cell division and cell differentiation (Biology B). Of particular use may be:
    - P.11-18 – detailed method
    - P.25 – task evaluating scientific drawings (answers on p.50)
    - P.28 – justifying method steps worksheet (answers on p.52)
    - P.29-31 – student method
    - P.32 – how to use a light microscope instruction sheet
    - P.34 – eyepiece graticule and stage micrometer instructions
    - P.39-47 – diagrams showing the stages in mitosis and suggestion of how to use them for magnification calculations.

There is also a quiz which can be used for formative assessment.

- **ALTERNATIVE PRACTICAL: Royal Society of Biology/ Nuffield Foundation – Measuring stomatal density**
  - https://pbiol.rsb.org.uk/exchange-of-materials/transpiration-in-plants/a-window-on-the-past-measuring-stomatal-density?highlight=WyJ0ZW1wZXJhdHVyZSJd
  - This resource includes an alternative practical technique making slides of leaf epidermis to measure stomatal density. Students could use an eyepiece graticule and stage micrometer to take measurements and make scientific drawings.
- **ALTERNATIVE PRACTICAL: Science Lessons That Rock – Setting up a hay infusion**
  - https://www.sciencelessonsthatrock.com/blog/setting-up-a-hay-infusion-for-your-microscope-unit
  - This resource discusses how to set up a hay infusion to observe protoctista under a wet mount. It includes a video of what can be expected.
- **MICROSCOPE CALIBRATION**
  - A number of resources exist to support with this:
    - https://gwhsasbiology.files.wordpress.com/2013/09/siz-and-scale.pdf
      - This resource includes some written instructions supported by a diagram and some questions.
    - https://www.yumpu.com/en/document/read/48719133/measuring-techniques-d3-university-of-michigan
      - This resource includes slides which talk through the process of calibrating a light microscope.
    - https://www.youtube.com/watch?v=cWBsDk6JGTg
      - This video gives a walkthrough of calibrating a light microscope in a standard school/college setup.

PAG 2: Dissection

Minimum techniques/ skills to be covered:

- Safe use of instruments for dissection of an animal or plant organ
- Use of a light microscope at high power and low power, use of a graticule
  - If not covered in **PAG 1**.
- Production of scientific drawings from observations with annotations
  - If not covered in **PAG 1** or **PAG 2**.

Suggested activities	1.2.1 practical skills covered	1.2.2 apparatus and techniques covered
2.1: Dissection of the mammalian heart	b, c, d, e, f, j	a, e, j
2.2: Dissection of a stem		a, d, e, j
2:3: Dissection of muscle fibres from chicken wings		e, j

Overview

This Practical Activity Group includes safe and correct use of practical equipment to perform a dissection. **PAG 2.1** and **PAG 2.3** involves the dissection of animal material which can easily be sourced from a supermarket or butchers. **PAG 2.2** involves plant material which is sometimes preferred by individual students.

Possible adjustments

For **PAG 2.1** lamb or pig hearts are usually used. It is possible to source larger ox hearts which are particularly good for demonstrating techniques or for when students are working in larger groups.

For **PAG 2.3** chicken wings are used. This could be adjusted to use different readily available animal material, such as chicken feet.

For **PAG 2.2** celery is used. This could be adjusted based on what is available – asparagus, carnations, sunflowers etc would all be suitable. It is worth pointing out that there are different arrangements in plants stems depending on if the plant is a dicot or monocot. The SAPS – Dissection of a plant resource below provides further detail on this.

To complete this PAG other dissections could be performed. Possible options include locusts, fish heads and flower dissections.

Support resources

These resources may be useful for teachers when planning/ adjusting PAGs or for students when they are revising for the specification's learning outcomes in 1.1 Practical skills assessed in a written examination.

- **HANDBOOK: OCR – Drawing Skills Handbook**
  - https://www.ocr.org.uk/Images/251799-biology-drawing-skills-handbook.pdf
  - This resource explains the requirements of good biological drawings and includes a common errors activity.
- **RESOURCED LESSON OUTLINE: Cambridge International – Heart dissection (PAG 2.1)**
  - https://learning.cambridgeinternational.org/classroom/course/view.php?id=3652
  - This is an excellent resource. It includes an excellent video (with transcript) which demonstrates a complete heart dissection alongside a digital diagram so parallels can be made between the two. It also has a teacher walkthrough

version of the video which includes additional safety considerations and teacher notes, as well as a virtual experiment video with questions for students to consider throughout. There is also a Teaching Pack which includes a scheme of work for 3 one hour long lessons around the dissection. This is much more in depth than is required to cover the PAG but could be very useful when teaching 3.1.2 Transport in animals (Biology A) or 2.2.1 The heart and monitoring heart function (Biology B). Of particular use may be:

- P.10-14 – detailed method
- P.18-19 – lesson plan and signposting to worksheets for completing the virtual experiment
- P.28-33 – student method
- P.34-43 – worksheets for recording observations.

- **DETAILED PRACTICAL: SAPS – Dissection of a plant stem (PAG 2.2)**
  - https://www.saps.org.uk/secondary/teaching-resources/1325-a-level-set-practicals-dissection-and-microscopy-of-a-plant-stem
  - This resource provides further detail on alternative plants to use for PAG 2.2 with teacher and student notes as well as a student worksheet.
- **ALTERNATIVE DISSECTION: Royal Society of Biology/ Nuffield Foundation – Dissection of the ventilation system of a locust**
  - https://pbiol.rsb.org.uk/cells-to-systems/ventilation-systems/dissection-of-the-ventilation-system-of-a-locust
  - This resource outlines a class practical dissecting a locust which links to 3.1.1 Exchange surfaces (Biology A).
- **ALTERNATIVE DISSECTION: OCR Topic Exploration Pack – Fish head dissection**
  - https://www.ocr.org.uk/Images/209191-mechanisms-of-ventilation-and-gaseous-exchange.pdf
  - This exploration pack includes an outline of a demonstration of a fish head dissection which could be adapted for students to complete their own fish head dissection which links to 3.1.1 Exchange surfaces (Biology A).
- **VIDEO: Samples for Schools – Fish head dissection**
  - https://www.youtube.com/watch?v=lfiJlY2ffkI
  - This video demonstrates the whole process of a fish head dissection.
- **ALTERNATIVE DISSECTION: SAPS – Dissection of a flower**
  - https://www.saps.org.uk/secondary/teaching-resources/1357-a-level-set-practicals-producing-a-scientific-drawing
  - This resource provides teacher/ technician and student notes as well as a support sheet and worksheet for completing a flower dissection.

PAG 3: Sampling techniques

Minimum techniques/ skills to be covered:

- Use of sampling techniques in fieldwork
- Production of scientific drawings from observations with annotations
    - If not covered in **PAG 1** or **PAG 2**.

Suggested activities	1.2.1 practical skills covered	1.2.2 apparatus and techniques covered
3.1: Calculation of species diversity	b, c, d, e, f, j	a, e, k
3.2: Measurement of the distribution and abundance of plants in a habitat		
3.3: Investigating a correlation between a named species and a biotic and/or abiotic factor	a, b, c, d, e, f, j	

Overview

This Practical Activity Group includes the practical use of sampling techniques in fieldwork.

PAG 3.1 involves randomly sampling two areas then calculating the species diversity index and making a conclusion.

PAG 3.2 involves taking an interrupted belt transect to measure the abundance of a range of plant species.

PAG 3.3 is an investigation in which any appropriate sampling technique is used to identify any correlation between the abundance of an animal species and a biotic factor.

Possible adjustments

When completing this PAG it is possible to adjust the sampling techniques and areas based on what is available locally as appropriate. For example:

- 1m x 1m quadrat is only a suggestion, it is possible to make the quadrats much smaller, say 0.2m x 0.2m or even 0.05m x 0.05m;
- Lengths of transects/ areas taken can be reduced from the suggested 20m/ 30m in the PAGs;
- Outdoor paved or brick flooring areas can be used looking at living organisms such as moss or lichen – for example, the abundance of a lichen species in a dry vs. damp location could be compared.
- Vertical surfaces can be used for areas, for example, species diversity index could be calculated for the north and south sides of a lamppost, tree or bus shelter, or the abundance of lichen species on a shaded wall vs an unshaded wall.

These adjustments could allow **PAG 3** to be carried out even in inner city locations.

PAG 3.3 is very flexible and there is plenty of scope for groups to investigate different factors. Although animal species abundance is suggested, it is possible to adjust this for plant species abundance if appropriate. Additionally, there is the possibility of this PAG being adjusted to address 1.2.1(h) (using online and offline research skills) and 1.2.1(i) (correctly citing sources of information) if a research element (such as into alternative sampling methods/ investigations) is added to this investigation. As part of completing **PAG 3.3** as an independent investigation there is the opportunity for 1.2.1(g) (use appropriate software and tools to process data, carry out research and report findings) to be addressed if a data logger is used to measure an abiotic factor, such as soil pH (this can then be an alternative to PAG **10.3**).

PAG 3.1, **PAG 3.2** and **PAG 3.3** can all be adapted to use alternative sampling techniques if appropriate, e.g. a point transect can be used.

Support resources

These resources may be useful for teachers when planning/ adjusting PAGs or for students when they are revising for the specification's learning outcomes in 1.1 Practical skills assessed in a written examination.

- **VIRTUAL INVESTIGATION: SAPS – Abundance and random sampling**
  - https://www.saps.org.uk/secondary/teaching-resources/768-ecology-practical-abundance-diversity-and-random-sampling
  - This is brilliant resource for comparing the abundance of plant species in two different locations. There are interactive areas, a plant ID sheet and tables for recording results. It is possible to perform species diversity index calculations and address 4.2.1 Biodiversity (Biology A) or 3.1.3 The development of species: evolution and classification (Biology B).
  - NOTE: Completing this virtual investigation is insufficient to meet this PAG, practical sampling techniques must be experienced.
- **ALTERNATIVE PRACTICAL: Air Pollution Information System - Monitoring air quality using lichens**
  - http://www.apis.ac.uk/nitrogen-lichen-field-manual#lichen%20field%20manual
  - This is a comprehensive resource based on investigating atmospheric nitrogen pollution on lichen species. It includes links to a Lichen Online Manual, an A4 pull-out field guide and recording forms with example data. Completing the whole investigation goes above the requirements for the PAG.
  - However, sampling lichen on trees or branches (or even walls, lampposts or bus shelters) with appropriate sized quadrats may be a more accessible option for this PAG for some centres. The A4 pull-out field guide provides a comprehensive key to identifying lichen which may be found in the UK.
- **LICHEN HANDBOOK: Forestry Commission – Lichens in southern woodlands**
  - https://www.forestresearch.gov.uk/documents/6718/FCHB004.pdf
  - This Forestry Commission handbook includes another useful photographic key to help with identifying lichen.
- **MEASURING SOIL pH: Field Studies Council – Abiotic factors: Soil (PAG 3.3)**
  - https://www.biology-fieldwork.org/a-level/fieldwork-techniques/abiotic-factors/soil/
  - This resource gives a guide to measuring soil pH which could be an abiotic factor investigated. Soil pH could be measured using an indicator or a data logger.
- **MODELLING SAMPLING: Teacher's Toolkit - An inquiry-based activity to show the importance of sample size and random sampling**
  - https://www.gvsu.edu/cms4/asset/BAC84988-C634-25FC-409B57A56DB3C9C8/random_sampling.pdf
  - This resource is focused on comparing random and biased sampling. However, it does give ideas on how to use sweets (Hershey's Kisses) to model dandelions. This could be adapted to model **PAG 3.1** or **PAG 3.2**.

PAG 4: Rate of enzyme-controlled reactions

Minimum techniques/skills to be covered:

- Use of appropriate apparatus to record a range of quantitative measurements (to include mass, time, volume, temperature, length and pH)
    - If not covered in **PAG 8**.
- Use of laboratory glassware apparatus for a variety of experimental techniques to include serial dilutions
    - If not covered in **PAG 5**, **PAG 7**, **PAG 8** or **PAG 9**.
- Use of ICT such as computer modelling, or data logger to collect data, or use of software to process data
    - If not covered in **PAG 8** or **PAG 10**.

Suggested activities	1.2.1 practical skills covered	1.2.2 apparatus and techniques covered
4.1: The effect of substrate concentration on the rate of an enzyme-controlled reaction	a, b, d, e, f, j	a
4.2: The effect of enzyme concentration on the rate of a reaction	b, c, d, e, f, j	a, c
4.3: Investigating the effect of temperature on amylase activity	a, b, d, e, f, j	a

Overview

This Practical Activity Group uses the context of enzymatic reactions to complete investigations. **PAG 4.1** and **PAG 4.2** are excellent for students to demonstrate their competence in performing serial dilutions.

Possible adjustments

The PAGs give three different options (**PAG 4.1** – substrate concentration; **PAG 4.2**– enzyme concentration; **PAG 4.3** – temperature) for independent variables when investigating rate of enzymatic action. Other independent variables could in used, e.g. pH.

In addition, the PAGs give two different options for measuring rate of reaction (**PAG 4.1** – collecting gas over water; **PAG 4.2** – "disappearing cross" method). Other techniques are possible if appropriate, such as using a gas syringe or change in mass.

PAG 4.3 suggests equipment but gives scope for independent design of an investigation. This could be adapted to address 1.2.1(h) (using online and offline research skills) and 1.2.1(i) (correctly citing sources of information) if a research element (such as into possible methods) is added to this investigation.

It is also possible to adjust the enzymes and substrates used in this PAG. Where students have already demonstrated their competence in making a serial dilution through a different PAG, **PAG 4.1** and **PAG 4.2** and can all be done with this part of the practical being completed by the teacher/ technician.

Support resources

These resources may be useful for teachers when planning/ adjusting PAGs or for students when they are revising for the specification's learning outcomes in 1.1 Practical skills assessed in a written examination.

- **ALTERNATIVE PRACTICAL: Royal Society of Biology/ Nuffield Foundation – Investigating an enzyme-controlled reaction: catalase and hydrogen peroxide concentration (PAG 4.1)**
  - https://pbiol.rsb.org.uk/bio-molecules/factors-affecting-enzyme-activity/investigating-an-enzyme-controlled-reaction-catalase-and-hydrogen-peroxide-concentration
  - This is an alternative practical procedure including method and student sheet where pureed potato is used as the source of catalase rather than potato cylinders.
- **ALTERNATIVE PRACTICAL: Royal Society of Biology/ Nuffield Foundation – Investigating effect of concentration on the activity of trypsin (PAG 4.2)**
  - https://pbiol.rsb.org.uk/bio-molecules/factors-affecting-enzyme-activity/investigating-effect-of-concentration-on-the-activity-of-trypsin
  - This resource gives an alternative method for **PAG 4.2** where photographic film is used instead of milk powder.
- **ALTERNATIVE PRACTICAL: CLEAPPS - Investigating the effect of lipase concentration on the rate of reaction (PAG 4.2)**
  - http://science.cleapss.org.uk/Resource/PP074-Investigating-the-effect-of-lipase-concentration-on-rate-of-reaction.pdf
  - This gives another alternative method for **PAG 4.2** where a change in pH is used to identify the rate of reaction as lipids are broken down into fatty acids and glycerol. This could be used to link to 2.1.2 Biological molecules (Biology A) or 2.1.1 Cells and microscopy (Biology B).
- **RESOURCED LESSON OUTLINE: Cambridge International – Investigating the effect of temperature on the rate of an enzyme-catalysed reaction (PAG 4.3)**
  - https://learning.cambridgeinternational.org/classroom/course/view.php?id=3636
  - This is a comprehensive resource. It includes a video (with transcript) which provides the outline of the investigation. There are two other versions of this video – a teacher walkthrough version which includes additional safety information and teacher notes and a virtual experiment version with questions for students to consider throughout. There is also a Teaching Pack which includes a scheme of work for 4 one hour long lessons around the investigation. This is much more in depth than is required to cover the PAG but does have very detailed guidance and some tasks which may be useful for students, of particular use may be:
    - P.11-15 – detailed notes, method with and sample results.
    - P.19-25 – relevant worksheets and answers.
- **ALTERNATIVE PRACTICAL: Royal Society of Biology/ Nuffield Foundation – Investigating effect of temperature on the activity of lipase (PAG 4.3)**
  - https://pbiol.rsb.org.uk/bio-molecules/factors-affecting-enzyme-activity/investigating-effect-of-temperature-on-the-activity-of-lipase
  - This resource gives a specific method and student sheet for an investigation where the independent variable is temperature as in **PAG 4.3**.
- **ALTERNATIVE PRACTICAL: CLEAPPS – Investigating the effect of temperature on amylase action (PAG 4.3)**
  - http://science.cleapss.org.uk/Resource/PP071-Investigating-the-effect-of-temperature-on-amylase.pdf
  - This resource gives a specific method and student sheet for an investigation where the independent variable is temperature as in **PAG 4.3** and the enzyme is amylase.
- **ALTERNATIVE PRACTICAL: Royal Society of Biology/ Nuffield Foundation – Investigating the effect of pH on amylase activity**
  - https://pbiol.rsb.org.uk/bio-molecules/factors-affecting-enzyme-activity/investigating-the-effect-of-ph-on-amylase-activity
  - This resource gives a specific method and student sheet for an investigation where the independent variable is the pH.

PAG 5: Colorimeter OR potometer

Minimum techniques/ skills to be covered:

- Use of appropriate instrumentation to record quantitative measurements, such as a colorimeter or potometer
- Use of laboratory glassware apparatus for a variety of experimental techniques to include serial dilutions
    - If not covered in **PAG 4**, **PAG 7**, **PAG 8** or **PAG 9**.

Suggested activities	1.2.1 practical skills covered	1.2.2 apparatus and techniques covered
5.1: The effect of temperature on membrane permeability	b, c, d, e, f, j	a, b
5.2: Determining glucose concentration		a, b, c
5.3: Using a potometer		a, b

Overview

This Practical Activity Group uses specific practical instrumentation to record quantitative measurements using either a colorimeter or a potometer.

Both **PAG 5.1** and **PAG 5.2** involve the use of colorimeters. **PAG 5.1** uses beetroot cylinders to investigate how temperature affects the membrane permeability of plant cells. It involves putting beetroot cylinders into different temperatures of water and measuring how much anthocyanin (purple pigment) leaves the cell surface membrane. **PAG 5.2** involves using known concentrations of glucose solution to produce a calibration curve, then using this calibration curve to identify the concentration of an unknown glucose solution.

PAG 5.2 provides the opportunity for students to complete a serial dilution.

PAG 5.3 involves using a potometer to measure the rate of transpiration of a leafy shoot in different conditions.

Possible adjustments

It is beneficial for students to use a colorimeter if it is possible to access one, although completing it is not necessary for this PAG. There is a further opportunity for students to use a colorimeter in **PAG 8.3** and to address **PAG 10** if the colorimeter is linked to a data logger. Additionally, for the PAG it is possible for students to use a colorimeter in a different context to that detailed in **PAG 5.1**. An example is given below where a colorimeter is used to identify the percentage of protein in a milk powder solution.

Where students have already demonstrated their competence in making a serial dilution through a different PAG, **PAG 5.2** can be done with this part of the practical being completed by the teacher/ technician.

PAG 5.3 gives one set up for a potometer. There are several types of potometer set ups and it is useful for students to be able to recognise all of these. Simple potometers can be made depending on the laboratory equipment available, see below for possible options. There is scope for **PAG 5.3** to address 1.2.1(h) (using online and offline research skills) and 1.2.1(i) (correctly citing sources of information) if a research element (such as into possible potometer set ups) is added to this investigation.

Support resources

These resources may be useful for teachers when planning/ adjusting PAGs or for students when they are revising for the specification's learning outcomes in 1.1 Practical skills assessed in a written examination.

- **RESOURCED LESSON OUTLINE: Cambridge International – Investigating the effect of temperature on the permeability of plant cell membranes (PAG 5.1)**
    - https://learning.cambridgeinternational.org/classroom/course/view.php?id=3638

- This is a comprehensive resource. It includes a video (with transcript) which provides the outline of the investigation as well as a teacher walkthrough version which includes additional safety information and teacher notes, as well as a virtual experiment video with questions for students to consider throughout. There is also a Teaching Pack which includes a scheme of work for 4 one hour long lessons around the investigation. This is much more in depth than is required to cover the PAG but does have very detailed guidance and some tasks which may be useful for students, of particular use may be:
  - P.11-15 – detailed notes, method with and sample results.
  - P.19-25 – relevant worksheets and answers.

- **DIY COLORIMETER: CLEAPPS – Make-it guide – colorimeters**
  - http://science.cleapss.org.uk/Resource/GL174-Make-it-guide-a-simple-colorimeter.pdf
  - This resource provides instructions for how to make a colorimeter. An additional support video is available here: http://science.cleapss.org.uk/Resource-Info/Setting-up-a-DIY-colorimeter.aspx.

- **ALTERNATIVE PRACTICAL: CLEAPPS - Investigating the breakdown of beetroot membranes (PAG 5.1)**
  - http://science.cleapss.org.uk/Resource/PP017-Investigating-the-breakdown-of-beetroot-membranes.pdf
  - This resource includes a method (including pictures) for investigating the effect of temperature on permeability across beetroot cell membranes. It details how quantitative measurements can be taken with a colorimeter and gives sample results. It could also be linked to **PAG 8.3**.

- **ALTERNATIVE PRACTICAL: Royal Society of Biology/ Nuffield Foundation - Quantitative food test: protein content of powdered milk (PAG 5.1)**
  - https://pbiol.rsb.org.uk/bio-molecules/quantitative-food-tests/quantitative-food-test-protein-content-of-powdered-milk
  - This resource provides an alternative practical method which encourages the use of a colorimeter in a different context. It includes sample results.

- **DETAILED POTOMETER SET UP: SAPS – Using a potometer (PAG 5.3)**
  - https://www.saps.org.uk/secondary/teaching-resources/1341-a-level-set-practicals-using-a-potometer
  - This resource provides further detail for PAG 5.3 with a video on how to set up the type of potometer included in the method, teacher and student notes as well as a student worksheet.

- **ALTERNATIVE POTOMETER SET UP VIDEO: STEM – Setting up a potometer (PAG 5.3)**
  - https://www.youtube.com/watch?v=gQG8UCPaF_I
  - This 16 minute video shows a Ganong's potometer set up using more specialised glassware which may be available for a demonstration. It gives good justification for the set up and suggests possible investigations which could be done. It also gives a possible set up for a student potometer using only capillary tubing and silicone tubing (from 10:45 minutes onwards).

- **ALTERNATIVE POTOMETER SET UP VIDEO: CLEAPPS – Setting up a potometer (PAG 5.3)**
  - http://science.cleapss.org.uk/Resource/Setting-up-a-Potometer.vid
  - This video shows another alternative potometer set up which uses general laboratory equipment.

- **DETAILED PRACTICAL: SAPS – Investigating transpiration with a potometer (PAG 5.3)**
  - https://www.saps.org.uk/secondary/teaching-resources/1263-investigating-transpiration-with-a-potometer
  - This resource includes student and teacher notes specifically on how to use a potometer to investigate how different factors affect rate of transpiration.

PAG 6: Chromatography OR electrophoresis

Minimum techniques/ skills to be covered:

- Separation of biological compounds using thin-layer/paper chromatography or electrophoresis

Suggested activities	1.2.1 practical skills covered	1.2.2 apparatus and techniques covered
6.1: Identification of the amino acids in a protein using paper chromatography	b, c, d, e, f, j	a, g
6.2: Electrophoresis of DNA fragments for analysis		
6.3: Investigation using thin-layer chromatography to separate photosynthetic pigments		

Overview

This Practical Activity Group involves using separating techniques to analyse biological compounds.

The practical techniques in **PAG 6.1** and **PAG 6.3** are very similar to those many students would have already completed in their prior study of Chemistry when separating ink or nail varnish. Therefore, they allow students to make links between Chemistry and Biology clearly. **PAG 6.1** involves using paper chromatography to separate a mixture of amino acids. **PAG 6.3** introduces thin-layer chromatography to students to separate photosynthetic pigments. Unless adapted as detailed below, both these PAG's require access to a fume cupboard. **PAG 6.1** requires a series of 3 lessons for the whole process while **PAG 6.3** is less time demanding and can be completed in one lesson.

PAG 6.2 requires specialist electrophoresis equipment which is often available through outreach opportunities with Universities. An alternative DIY version is detailed below.

Possible adjustments

As **PAG 6.2** is sometimes not accessible for centres where they cannot access the needed equipment we have an adapted microscale version which is detailed below. This can be adapted to run naturally occurring pigments which are biological compounds.

PAG 6.3 can be adapted to be completed without a fume cupboard if required, see the methods below from SAPS and CLEAPPS.

It is possible to adapt **PAG 6.1** and **PAG 6.3** and complete paper chromatography of photosynthetic pigments. This may be helpful if laboratory equipment/ chemical access is difficult. See the below methods from the Royal Society of Chemistry/ Nuffield Foundation.

Support resources

These resources may be useful for teachers when planning/ adjusting PAGs or for students when they are revising for the specification's learning outcomes in 1.1 Practical skills assessed in a written examination.

- **ALTERNATIVE PRACTICAL: CLEAPPS – Paper chromatography of amino acids (PAG 6.1)**
  - http://science.cleapss.org.uk/Resource/PP062-Paper-chromatography-of-amino-acids.pdf
  - This is a simple procedure sheet with a very similar method to the one in **PAG 6.1**, it still requires the use of a fume cupboard. It includes pictures of the method and an example chromatogram to show what is expected.

- **ALTERNATIVE PRACTICAL: OCR – Simple gel electrophoresis**
  - https://www.ocr.org.uk/Images/577236-microscale-gel-electrophoresis.docx
  - This gives instructions for how to make a simple gel electrophoresis tank using regular laboratory equipment and suggests how to use it to separate food colourings. This tank could be used to complete **PAG 6.2** if natural food colourings are used as these will contain biological pigments. Natural food colourings could be sourced or extracted using instructions such as these https://melscience.com/US-en/articles/homemade-food-colorings-experiment/ or these https://www.biggerbolderbaking.com/all-natural-homemade-food-coloring/.
- **RESOURCED LESSON OUTLINE: Cambridge International – Investigating how gel electrophoresis is used to separate DNA fragments of different lengths (PAG 6.2)**
  - https://learning.cambridgeinternational.org/classroom/course/view.php?id=3734
  - This details the whole process of using gel electrophoresis to separate DNA fragments. It includes a video (with transcript) which provides the outline of the investigation as well as a teacher walkthrough version which includes additional safety information and teacher notes. There is also a Teaching Pack which includes a scheme of work for 4 one hour long lessons around the investigation. Of particular use may be:
    - P.12-15 – detailed notes and method.
    - P.17-48 – relevant worksheets and answers.

There is also an online quiz which can be used for formative assessment and a link to topic questions (although these are written for the Cambridge International A Level Biology the questions do provide good exam practice with otherwise unseen questions).

- **ALTERNATIVE PRACTICAL: SAPS – TLC of plant photosynthetic pigments (PAG 6.3)**
  - https://www.saps.org.uk/secondary/teaching-resources/1347-a-level-set-practials-tlc
  - This resource includes a video, teacher notes, a student sheet and worksheet for an alternative practical technique for completing thin-layer chromatography when a fume cupboard is not available.
- **ALTERNATIVE PRACTICAL: CLEAPPS – Thin-layer chromatography of plant pigments (PAG 6.3)**
  - http://science.cleapss.org.uk/Resource/PP056-Thin-layer-chromatography-of-plant-pigments.pdf
  - This is a simple procedure sheet with a very similar method to the SAPS one above and also does not require a fume cupboard. It includes pictures of the method and example results plates to show what is expected.
- **ALTERNATIVE PRACTICAL: Royal Society of Chemistry/ Nuffield Foundation – Chromatography of leaves**
  - https://edu.rsc.org/resources/chromatography-of-leaves/389.article
  - This is a combination of **PAG 6.1** and **PAG 6.3** where paper chromatography of photosynthetic pigments is completed. It takes only 30 minutes to complete and uses regular laboratory equipment, no TLC plates or fume cupboard are necessary.

PAG 7: Microbiological techniques

Minimum techniques/ skills to be covered:

- Use of laboratory glassware apparatus for a variety of experimental techniques to include serial dilutions
  - If not covered in PAG 4, PAG 5, PAG 8 or PAG 9.
- Use of microbiological aseptic techniques, including the use of agar plates and broth

Suggested activities	1.2.1 practical skills covered	1.2.2 apparatus and techniques covered
7.1: The effect of antibiotics on bacterial growth	b, c, d, e, f, j	a, e, i
7.2: Dilution plating to determine microbial density in liquid culture		a, c, e, i
7.3: Transformation of bacteria with plasmid encoding GFP		e, i

Overview

This Practical Activity Group involves best practice of handling microorganisms using aseptic technique.

PAG 7.1 and **PAG 7.2** both require students to prepare a bacterial spread plate. **PAG 7.2** provides the opportunity for students to complete a serial dilution.

PAG 7.3 involves transforming bacteria with the gene for green fluorescent protein so the bacteria will fluoresce under UV light. This PAG includes preparing a bacterial streak plate, transforming the bacteria and then observing them so is quite time and equipment/ materials intensive.

Possible adjustments

There are many investigations which students could research to adjust this PAG to address 1.2.1(h) (using online and offline research skills) and 1.2.1(i) (correctly citing sources of information). Additionally, teachers can identify an appropriate practical for their centre's circumstances if the focus remains on student's developing competence in aseptic technique. The Microbiology Society resource below is a good starting point.

Where students have already demonstrated their competence in making a serial dilution through a different PAG, **PAG 7.1** and **PAG 7.2** can be done with this part of the practical being completed by the teacher/ technician.

Support resources

These resources may be useful for teachers when planning/ adjusting PAGs or for students when they are revising for the specification's learning outcomes in 1.1 Practical skills assessed in a written examination.

- **GUIDANCE LEAFLET: CLEAPSS – Aseptic techniques in microbiology**
  - http://science.cleapss.org.uk/Resource/GL270-Aseptic-techniques-in-microbiology.pdf
  - This leaflet gives concise information on aseptic techniques in the school laboratory.
- **GUIDANCE LAFLET: Microbiological Society – Basic Practical Microbiology manual**
  - https://microbiologysociety.org/publication/education-outreach-resources/basic-practical-microbiology-a-manual.html
  - This is a more comprehensive guide to aseptic techniques and is intended for teachers and technicians.

- The Royal Society of Biology/ Nuffield Foundation have summarised this guide here:
  - https://pbiol.rsb.org.uk/standard-techniques/aseptic-techniques.

- **ALTERNATIVE PRACTICALS: Microbiology Society – Practical microbiology for secondary schools**
  - https://microbiologysociety.org/publication/education-outreach-resources/practical-microbiology-for-secondary-schools.html
  - This is a comprehensive handbook with teacher and student guides for many different practicals which could be adapted to complete this PAG. Of particular use may be:
    - P.8-9 – Estimating the number of bacteria in water. This is a variation of **PAG 7.2** involving students estimating the microbial population of natural waters.
    - P.10-11 – Breakdown of starch by microbes. This demonstrates how bacteria can produce amylases to digest starch. It uses a technique similar to that in **PAG 7.1**.
    - P.12-13 – Breakdown of protein by microbes. This is a slightly different approach to the other PAGs but is a great option for an investigation around the digestion of proteins which requires aseptic technique.
    - P.24-25 – Isolating microbes from root nodules. This practical is excellent to complete alongside 6.3.1 Ecosystems (Biology A) or 4.3.1 Photosynthesis, food production and management of the environment (Biology B). It involves students using aseptic technique to isolate and grow a *Rhizobium* population.
    - P.40-41 – Effects of antiseptics on microbes. This is an alternative practical procedure to **PAG 7.1**.

PAG 8: Transport in and out of cells

Minimum techniques/ skills to be covered:

- Use of appropriate apparatus to record a range of quantitative measurements (to include mass, time, volume, temperature, length and pH)
    - If not covered in **PAG 4**
- Use of laboratory glassware apparatus for a variety of experimental techniques to include serial dilutions
    - If not covered in **PAG 4**, **PAG 5**, **PAG 7** or **PAG 9**.
- Use of ICT such as computer modelling, or data logger to collect data, or use of software to process data
    - If not covered in **PAG 4** or **PAG 10**.

Suggested activities	1.2.1 practical skills covered	1.2.2 apparatus and techniques covered
8.1: An investigation into the water potential of potato	b, c, d, e, f, j	a, c
8.2: Investigating osmosis in an artificial cell		
8.3: Investigating the rate of diffusion through a membrane	a, b, d, e, f, j	a, b, c

Overview

PAG 8.1 is the traditional investigation into water potential using potato cylinders which many students may be familiar with already.

PAG 8.2 uses dialysis tubing/ visking tubing to model a cell and investigates how putting cells in different concentrations of sucrose solution affects the mass of the cells.

PAG 8.3 gives brief guidance for an investigation into how washing up liquid affects the membrane structure of beetroot cylinders and therefore the rate of betalain diffusion.

PAG 8.1, **PAG 8.2** and **PAG 8.3** all provide excellent opportunities for students to demonstrate their competence in completing a serial dilution.

Possible adjustments

There are many ways to adjust **PAG 8.1**. Where students do not need to use this PAG to demonstrate their competence in completing a serial dilution, different independent variables could be chosen, such as different solutions (e.g. orange juice, milk, saline) or different vegetable/ plant material (e.g. courgette, carrot) depending on what is available. See the OCR blog below for further ideas. If students are given the independence to develop their own investigation this is another opportunity for them to meet 1.2.1(h) (using online and offline research skills) and 1.2.1(i) (correctly citing sources of information). Additionally, it is possible to complete **PAG 8.1** in a non-laboratory setting.

Additionally, **PAG 8.2** can be adapted to use different solutions as variables. It could also be adjusted to model the gut where transport in and out of multiple cells on a larger scale is addressed.

PAG 8.3 gives guidance for a variation of **PAG 5.1** so this gives students another opportunity to revise and demonstrate their use of a colorimeter. Additionally, it gives scope for independent design of an investigation which could address 1.2.1(h) (using online and offline research skills) and 1.2.1(i) (correctly citing sources of information) if a research element (such as into possible methods) is added to this investigation.

Where students have already demonstrated their competence in making a serial dilution through a different PAG, **PAG 8.1**, **PAG 8.2** and **PAG 8.3** can all be done with this part of the practical being completed by the teacher/ technician.

Support resources

These resources may be useful for teachers when planning/ adjusting PAGs or for students when they are revising for the specification's learning outcomes in 1.1 Practical skills assessed in a written examination.

- **RESOURCED LESSON OUTLINE: Cambridge International – Investigating the effect of osmosis on plant tissues (PAG 8.1)**
  - https://learning.cambridgeinternational.org/classroom/course/view.php?id=3647
  - This comprehensive resource includes an information and practical outline video (with transcript). It also has a teacher walkthrough version of the video which includes additional safety considerations and teacher notes, as well as a virtual experiment video with questions for students to consider and links to the worksheets throughout. There is also a Teaching Pack which includes a scheme of work for 3 one hour long lessons around the investigation. Of particular use may be:
    - P.10-13 – detailed notes and method.
    - P.18-50 – relevant worksheets and answers.

There is also an online quiz which can be used for formative assessment.

- **BLOG: OCR – Practical biology at home – osmosis (PAG 8.1)**
  - https://www.ocr.org.uk/blog/practical-biology-at-home-osmosis/
  - This blog details possible variations that can be made to the investigation into the water potential of a potato.
- **ALTERNATIVE PRACTICAL: Royal Society of Biology/ Nuffield Foundation - Evaluating Visking tubing as a model for a gut**
  - https://pbiol.rsb.org.uk/exchange-of-materials/digestion-and-absorption/evaluating-visking-tubing-as-a-model-for-a-gut
  - This resource includes the method for using visking tubing to model a gut which is a variation of **PAG 8.2**.
- **VIDEO: Gatsby Charitable Foundation/ National Science and Engineering Week – Visking tubing**
  - https://www.stem.org.uk/resources/elibrary/resource/34378/visking-tubing
  - This 8 minute video demonstrates how to use visking tubing in the context of demonstrating diffusion of glucose through a partially permeable membrane.
- **ALTERNATIVE PRACTICAL: CLEAPPS - Investigating the breakdown of beetroot membranes (PAG 8.3)**
  - http://science.cleapss.org.uk/Resource/PP017-Investigating-the-breakdown-of-beetroot-membranes.pdf
  - This resource gives a method (including pictures) for investigating the effect of ethanol on diffusion across beetroot cell membranes. It details how both qualitative observations can be made and how quantitative measurements can be taken with a colorimeter (which could link to **PAG 5.1**). It also gives sample results.

PAG 9: Qualitative testing

Minimum techniques/ skills to be covered:

- Use of laboratory glassware apparatus for a variety of experimental techniques to include serial dilutions
  - If not covered in **PAG 4**, **PAG 5**, **PAG 7** or **PAG 8**.
- Use of qualitative reagents to identify biological molecules

Suggested activities	1.2.1 practical skills covered	1.2.2 apparatus and techniques covered
9.1: Qualitative testing for biological molecules – proteins (Biuret test)	b, c, d, e, f, j	f
9.2: Qualitative testing for biological molecules – lipids (emulsion test)		
9.3: Qualitative testing for biological molecules – glucose (Benedict's test)		

Overview

This Practical Activity Group includes students testing for biological molecules. Each test is short and it can be possible to complete all three in one lesson while teaching 2.1.2 Biological molecules (Biology A) or the Biuret and Benedict's test while teaching 2.1.2 Water and its importance in plants and animals (Biology B).

Possible adjustments

It is possible to complete **PAG 9.1** in a non-laboratory setting. Additionally, for **PAG 9.1**, **PAG 9.2** and **PAG 9.3** different food items/ solutions can be used as appropriate.

It is possible to complete this PAG using a different method for qualitative testing. Examples could include using DCPIP to test for vitamin C and the Sudan III test for lipids. It could be an option for students to address 1.2.1(h) (using online and offline research skills) and 1.2.1(i) (correctly citing sources of information) by researching and comparing different tests for the same biological molecule.

Support resources

These resources may be useful for teachers when planning/ adjusting PAGs or for students when they are revising for the specification's learning outcomes in 1.1 Practical skills assessed in a written examination.

- **RESOURCED LESSON OUTLINE: Cambridge International – Food tests (PAG 9.1, PAG 9.2, PAG 9.3)**
  - https://learning.cambridgeinternational.org/classroom/course/view.php?id=3648
  - This comprehensive resource includes an information and practical outline video (with transcript) detailing the biological molecule tests for all 3 PAGs. It also has a teacher walkthrough version of the video which includes additional safety considerations and teacher notes, as well as a virtual experiment video with questions for students to consider and links to the worksheets throughout. There is also a Teaching Pack which includes a scheme of work for 3 one hour long lessons around the investigation. Of particular use may be:
    - P.11-17 – detailed notes and method.
    - P.24-51 – relevant worksheets and answers.
  - There is also an online quiz which can be used for formative assessment.
  - This resource also includes details on how to use DCPIP to test for vitamin C.
- **DETAILED PRACTICAL: CLEAPPS – Food tests (PAG 9.1, PAG 9.2, PAG 9.3)**
  - http://science.cleapss.org.uk/Resource/GL018-Food-tests.pdf
  - This resource gives methods and visual instructions for the food tests, including the Sudan III test for lipids.

PAG 10: Investigation using a data logger OR computer modelling

Minimum techniques/ skills to be covered:

- Use of ICT such as computer modelling, or data logger to collect data, or use of software to process data
    - If not covered in PAG 4 or PAG 8.

Suggested activities	1.2.1 practical skills covered	1.2.2 apparatus and techniques covered
10.1: Investigating DNA structure using RasMol	c, d, e, f, g, j	a, b, l
10.2: Turbidity change in microbial growth in different sugars	a, b, d, e, f, g, j	
10.3: Measuring pH change during yoghurt production		a, c, l

Overview

This Practical Activity Group is the main one where students can cover 1.2.1(g) Use appropriate software and tools to process data, carry out research and report findings.

PAG 10.1 gives the opportunity for students to visualise DNA structure as a 3d model. The instructions in the student and teacher sheets are comprehensive, although liaising with your IT department will be required to ensure the RasMol programme is installed on the machines that students will be using. Additionally, students may not be able to download the .PDB file from the Protein Data Bank themselves – if this is the case the file can be saved on a shared area that students can access.

PAG 10.2 gives another opportunity to that in **PAG 5.1** and **PAG 8.3** for students to use a colorimeter. This PAG requires students to set up a yeast suspension in different sugar solutions and then return to take readings of their turbidity at regular intervals.

PAG 10.3 uses a pH meter/ data logger to monitor how pH changes as yoghurt is made.

Possible adjustments

It is possible for **PAG 10.1** to be adapted to use other software which models biological structures, an example of this is the Biotopics resource given below.. Alternatively, the RasMol software can be used to explore a different biological structure.

For both **PAG 10.2** and **PAG 10.3** PAG documents give suggested instructions. It is possible to adapt these into investigations which address 1.2.1(h) (using online and offline research skills) and 1.2.1(i) (correctly citing sources of information) if a research element (such as into the background information which would allow students to make informed predictions/ conclusions) is added into the PAGs.

Support resources

These resources may be useful for teachers when planning/ adjusting PAGs or for students when they are revising for the specification's learning outcomes in 1.1 Practical skills assessed in a written examination.

- **ALTERNATIVE SOFTWARE: Biotopics – 3-D interactive structures of biological molecules (PAG 10.1)**
  - https://www.biotopics.co.uk/jsmol/jscontents.html
  - This website provides a comprehensive set of 3d models of biological molecules which can be interacted with intuitively. Comparisons in structure between different molecules (e.g. α-glucose and β-glucose; amino acids) can be made.
- **ALTERNATIVE DATA LOGGING A LEVEL PRACTICALS: Data Harvest – A Level Practical Skills matches**
  - https://store.data-harvest.co.uk/secondary-teaching-materials
  - This handbook can be downloaded for free. It includes teacher's notes and student sheets with methods and questions for 15 Biology practicals which use data loggers. A number of these can be used to also address PAG 5.2 if a colorimeter is incorporated.
- **ALTERNATIVE DATA LOGGING QUICK PRACTICALS: Data Harvest – 5 minute activities**
  - https://store.data-harvest.co.uk/secondary-teaching-materials
  - This handbook can be downloaded for free. It includes quick practical activities which use data loggers. Of particular note are:
    - Activity 11 – Heart rate and Activity 25 – Heart rate and exercise
      - This could be linked to PAG 11.1.
    - Activity 15 – Transpiration: Water loss from plants

PAG 11: Investigation into the measurement of plant or animal responses

Minimum techniques/ skills to be covered:

- Safe and ethical use of organisms to measure plant or animal responses and physiological functions

Suggested activities	1.2.1 practical skills covered	1.2.2 apparatus and techniques covered
11.1: Investigation into the effect of exercise on pulse rate	a, b, c, d, e, f, j	a, h
11.2: Daphnia heart rate response to changes in surrounding medium	a, b, d, e, f, j	a, d, e, h
11.3: Practical investigation into phototropism		a, h
11.4: Practical investigation into the effect of plant hormones on growth		

Overview

This Practical Activity Group focuses on the safe and ethical use of living organisms in the context of measuring responses.

PAG 11.1 involves the students themselves completing exercise and measuring their pulse rate and minimal equipment is needed.

PAG 11.2 requires access to *Daphnia* and investigates how their heart rate changes with temperature. This can be an interesting introduction to the involvement of animals in scientific study for students.

PAG 11.3 and **PAG 11.4** both involve plant responses and are often best conducted over a series of days/ weeks.

Possible adjustments

PAG 11.1 does not require any laboratory access but does need a reasonable number of volunteers to enable statistical analysis of the results. This may be achievable in usual classes or additional volunteers might need to be sought. If available, it may be possible to continuously record pulse rate using a data logger which could address **PAG 10** – PE departments in schools may have access to the equipment needed to do this. A variation of this could be to record student's body temperature using a data logger throughout the exercise period.

It is possible to adapt **PAG 11.2** to investigate *Daphnia* with a different independent variable, although care should be taken regarding the ethics of this. It can be difficult to keep up with the counting the heart rate of the Daphnia so this can be videoed and replayed in slow-motion, see the CLEAPPS resource below.

PAG 11.3 and **PAG 11.4** can be set up at the beginning of a lesson and then checked at the end/ over the next few days/ weeks. The sheets indicate the use of maize but other seeds or coleoptiles can be used as available – cress is easy to source and works brilliantly over a short period of time. This can be completed in a non-laboratory setting as appropriate. Students are often familiar with observing phototropism in plants already.

PAG 11.2 and **PAG 11.3** are both brilliant opportunities for giving students the independence to design their own investigation which could address 1.2.1(h) (using online and offline research skills) and 1.2.1(i) (correctly citing sources of information) if they conduct their own research and reference it correctly.

Support resources

These resources may be useful for teachers when planning/ adjusting PAGs or for students when they are revising for the specification's learning outcomes in 1.1 Practical skills assessed in a written examination.

- **ALTERNATIVE INVESTIGATION: Royal Society of Biology/ Nuffield Foundation/ Royal Pharmacological Society – Investigating factors affecting the heart rate of *Daphnia* (PAG 11.2)**
    - https://pbiol.rsb.org.uk/control-and-communication/control-of-heart-rate/investigating-factors-affecting-the-heart-rate-of-daphnia
    - This resource provides a detailed method for investigating *Daphnia* heart rate. It includes how to use temperature or ethanol concentration as the independent variable.
- **ALTERNATIVE INVESTIGATION: CLEAPPS – Using the *Daphnia* heart as a model for the human heart) (PAG 11.2)**
    - http://science.cleapss.org.uk/Resource/TL019-Using-the-Daphnia-heart-as-a-model-for-the-human-heart.pdf
    - This provides a detailed pictorial method for recording video to aid with counting the heart rate of *Daphnia*. It details several independent variables which could be investigated.
- **ALTERNATIVE PRACTICAL: SAPS – Phototropism: the response of seedlings to light (PAG 11.3)**
    - https://www.saps.org.uk/secondary/teaching-resources/185-student-sheet-8-the-response-of-seedlings-to-light-phototropism-experiment
    - This resource provides student worksheet which gives a brief overview of an alternative practical which addresses how different light filters affect how seedlings grow. The student sheet provides suggestions of questions for students to consider while writing an investigation.
- **WRITTEN EXERCISE: Royal Society of Biology/ Nuffield Foundation – Interpreting an investigation of plant hormones (PAG 11.4)**
    - https://pbiol.rsb.org.uk/control-and-communication/homeostasis/interpreting-an-investigation-of-plant-hormones
    - This resource provides a written activity where students evaluate an investigation into plant hormones. It includes a student sheet with answers which could be used as in individual, group or whole class activity.

PAG 12: Research skills

Minimum techniques/ skills to be covered:

- Apply investigative approaches
- Use online and offline research skills
- Correctly cite sources of information

Suggested activities	1.2.1 practical skills covered	1.2.2 apparatus and techniques covered
12.1: Investigation into the respiration rate of *Saccharomyces* cerevisiae	a, b, d, e, f, g, h, i, j	a
12.2: Genetic crosses in fruit flies and their statistical analysis		a, h
12.3: Investigating the rate of oxygen production in pondweed		a

Overview

This Practical Activity Group provides a practical based context where students can demonstrate their ability to research and complete an investigation then reference their research appropriately. There are many ways throughout the other PAGs where students could meet the 1.2.1 practical skills mapped to **PAG 12.**

PAG 12.1 involves students independently/ as a group researching and developing a practical method to investigate how a factor affects the respiration rate of yeast. It links very closely with **PAG 10.2**.

PAG 12.2 involves students using fruit flies as a model organism to investigate inheritance of certain traits in multiple generations. It is a brilliant introduction to using a model organism with a short lifecycle in genetic experiments. It can link very closely to the ethical considerations in **PAG 11.2**.

PAG 12.3 is a development of the rate of photosynthesis in pondweed practical which many students will already be familiar with. This PAG gives students the scope to independently tailor this classic experiment into their own investigation and explain their predictions/ conclusions using their research.

Possible adjustments

There are endless possibilities with PAG 12 as long as the focus remains on students researching and performing an investigation and referencing their research appropriately. There are of course a number of acceptable techniques for referencing research and any of these are appropriate for **PAG 12**. If it is being completed when students are investigating Universities it could be an option for them to look up and use one of their potential University's referencing guide.

Support resources

This resource may be useful for teachers when planning how students may meet the research and referencing element of this PAG.

- **SKILLS GUIDE: OCR – THE OCR GUIDE TO REFERENCING**
  - https://www.ocr.org.uk/Images/570838-guide-to-referencing.pdf
  - This is one guide to appropriate referencing.
- **CREST AWARD: British Science Association**
  - https://www.crestawards.org/
  - An opportunity for students to use their research work on PAG12 as an extended project.
  - There is an example of how it can be used (https://secondarylibrary.crestawards.org/investigative-practical-science-in-the-curriculum/65418842)

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